

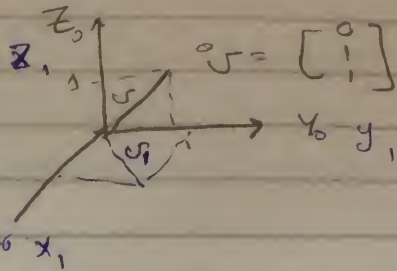
Sec: Robotics

eng: shehab

Rotation Matrix :-

- ① orientation of frame wrt another frame
- ② Co-ordinates of point P wrt _____.
- ③ Rotation operator Z_{11}

attached to frame 1



$$c = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

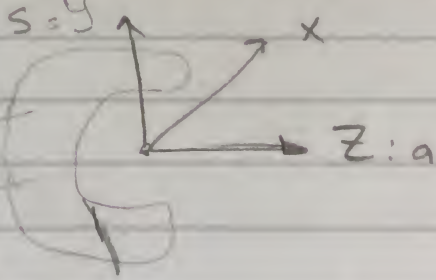
re 5° Pranas, 1981;
Rotation at Welo

و لكن ψ هو الى هتغير .

$$\mathbf{U}_{\text{new}} = \mathbf{R}_i \mathbf{U}_{\text{Previous}}$$

France " \leftarrow

frame 111 object 1 attach ← frame 111 object 1 x
111 frame 111 object 1 attach ← frame 111 object 1 x



a - appropriate

$S \rightarrow \text{slider}$

« علشان اقدر امسكه ان لجزءه من الفراح بوجه عام »

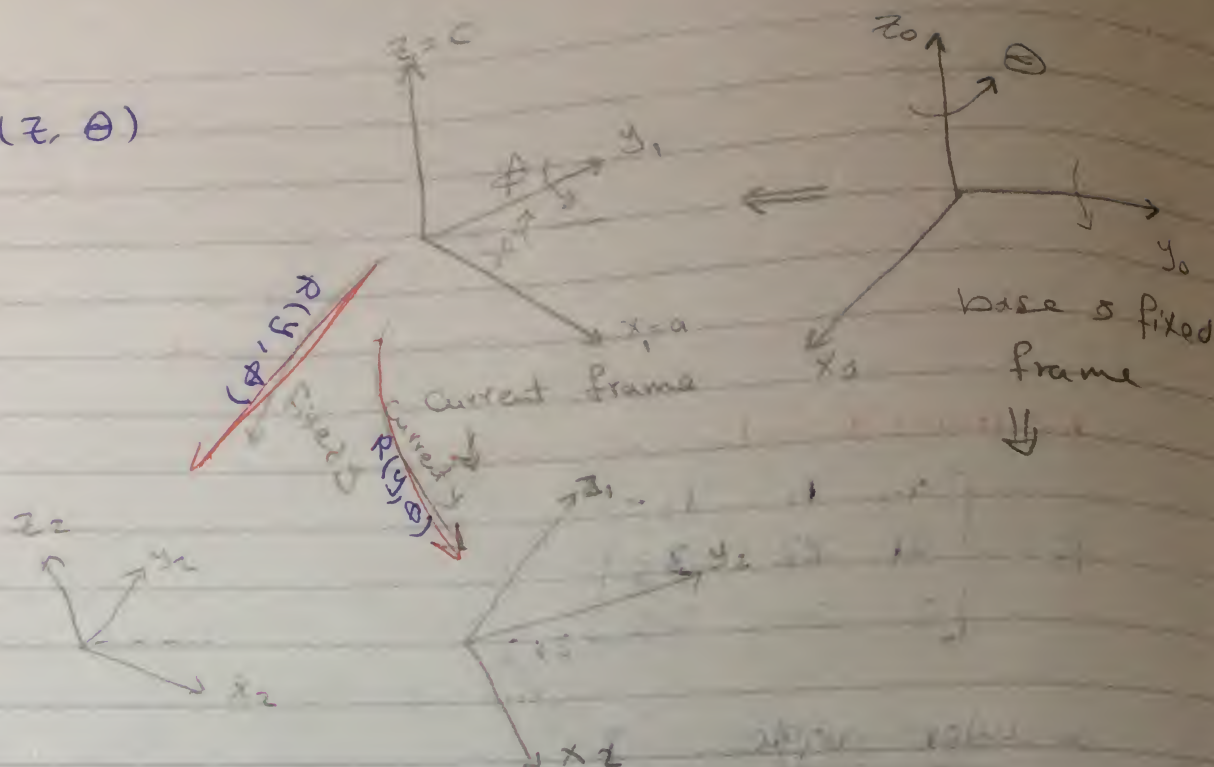
end effector is also orientation, and also

* Composition of Rotations:-

Successive Rotation.

موجودہ ذرائع rotation کی سطح پر اقبال علی orientation عام
نی الفرائح

$R(z, \theta)$



Pre multiplication, then \hat{J}_{base} fixed frame \rightarrow Rotation of ①
 Post multiplication, then \hat{J}_{current} current frame \leftarrow Rotation of ⑤

Case 1 :-

$$R = R(z, \theta) I R(y, \phi)$$

Case 2 :-

$$R = R(y, \phi) \cdot R(z, \theta) I$$

ex:

Rotation matrix R :

- 1- rotation of θ about Current x -axis
- 2- Rotation — ϕ — z -axis
- 3- — α — fixed z -axis
- 4- — β — Current y -axis
- 5- — γ — fixed x -axis

fixed frame \rightarrow kinematic frame
 Current frame \sim

$$R = R(x, \delta) R(z, \alpha) \quad \text{I} \quad R(x, \theta) R(z, \phi) R(y, \beta)$$

* Parametrization of matrix:-

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}_{3 \times 3} \quad \text{(Current Frame)}$$

* Euler angles: I

representation

$$\begin{matrix} Z_\theta & Y_\phi & Z_\psi \\ \downarrow & \downarrow & \downarrow \\ A & B & C \end{matrix}$$

حاصل جولين ال Z بزاوية ψ و بعد من
 بلفا حول ال Y بزاوية ϕ
 و بعد من Z بزاوية θ

$$\rightarrow I = R = R(Z, \phi) R(Y, \theta) R(Z, \psi)$$

$$R = \begin{bmatrix} \cos\phi \cos\theta & \cos\phi \sin\theta & -\sin\phi \\ \sin\phi \cos\theta & \sin\phi \sin\theta & \cos\phi \\ -\sin\theta & \cos\theta & 0 \end{bmatrix}$$

orientation of the frame after Euler angle \rightarrow Euler angle
 في الزاوية ال θ ال ϕ ال ψ من الفراغ

* Euler representation II

$$\begin{matrix} Z_\theta & X_\phi & Z_\psi \\ \downarrow & \downarrow & \downarrow \\ A & B & C \end{matrix}$$

$$R = R(Z, \phi) R(Y, \theta) R(Z, \psi)$$

* Roll, Pitch, Yaw

$x \rightarrow y \rightarrow z$

$$R = R(z, \theta) \cdot R(y, \phi) \cdot R(x, \psi)$$

